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The Effect of Government Deficits on Consumption and Interest Rates: A Two Equation Approach

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Abstract

Single-equation estimation of the consumption function often is used in testing the Ricardian equivalence theorem. This approach may be misleading, as effects on interest rates usually are ignored. This paper proposes simultaneous estimation of consumption and investment equations, with the interest rate serving to equilibrate the market. Five existing studies are replicated and subjected to sensitivity tests. The results show that the interest rate is important in the consumption function. The Ricardian equivalence theorem is tested, but the results are mixed.

Introduction

Over the last decade and a half, economists studying government deficits and interest rates have failed to establish a clear empirical relationship between the two variables. Previous studies have tested a variety of hypotheses using a number of different models, but almost all have ignored the interest rate as a variable affecting savings and consumption. This is surprising and disappointing from a theoretical point of view because the literature on the burden of the debt suggests that government deficits impose a burden on future generations primarily when they cause interest rates to rise.[1] Because interest rates are determined by market demand and supply, empirical testing requires a simultaneous-equations approach.

In this paper, the misinterpretations that arise from single-equation estimation of consumption equations are demonstrated. Several results from the empirical literature are replicated and shown to lack robustness, suggesting specification error.[2] Alternative hypotheses are nested, following the approach of Feldstein [13] and Kormendi [19]. New evidence is presented that shows that the use of simultaneous-equations techniques improves the specifications. The new results are not entirely robust, however, as they ignore some other important factors from macroeconomic theory.

Many of the empirical results on the effects of deficits are tests of the Ricardian equivalence theorem. Much of the testing began after Barro [1] revitalized interest in the theorem and began exploring the implications of debt neutrality for public policy. Table 1 shows the results in this literature, categorized by whether the test involves a deficit variable, a debt variable, or a Social Security wealth variable. This paper asks if these results can be reconciled. It suggests that a more complete model estimated using simultaneous-equations techniques can provide a partial reconciliation of these results. The single-equation results in the literature are misleading if interest rates are important in determining savings and investment.

Misinterpreting Single-Equation Results
The Burden of the Debt

Paradoxically, most of the current literature on testing the Ricardian equivalence theorem ignores interest rates, even though the theorem concerns the response of interest rates to changes in government deficits and debt. The interest rate is an important variable primarily because it is largely through a rise in interest rates that deficits are a burden on future generations.

This paper's main concern is with the effects of debt-financing versus tax-financing of a given amount of government spending; this is a differential-incidence analysis (in public finance terminology). If a government deficit causes consumption to rise, then investment must be crowded out (in a full employment context). This happens through an increase in interest rates. Consumption rises in response to a deficit in several cases. If consumption is a function of disposable income, then a tax cut that causes a higher deficit leads to higher consumption. If government debt is part of private net wealth and consumption is a function of wealth, then higher government debt implies higher wealth. Consumption rises. In either case, interest rates must rise. This does not happen if consumption is unaffected by a change in the deficit, as suggested by the Ricardian equivalence theorem.

The Ricardian Equivalence Theorem

The Ricardian equivalence theorem (RET) proposes that the choice of financing some part of government expenditures by debt rather than by taxes has no effect on real economic variables such as consumption

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and investment. The theorem's main argument is that individuals see their future tax liabilities as being just equal in present value to the debt. Thus a reduction in current taxes leads persons to increase their savings by exactly the amount of the tax cut, enabling them to pay the increased taxes in the future. The RET has received its strongest and most rigorous treatment from Barro [1, 2, 3].

A simple model of saving and investment is used to illustrate how the Ricardian equivalence theorem works. The RET and an alternative Keynesian approach are nested within the same model, following the Feldstein-Kormendi nesting method. At equilibrium, investment plus the government deficit (I + DEF) must equal savings (S).[3] Figure 1 graphs investment plus the government deficit and savings versus the interest rate (R). Consider an initial equilibrium with income Y_0, government spending level G_0, and taxes T_0, where at equilibrium savings is S_0 and the interest rate is R_0. What are the effects of a tax cut to T_1? Assume that the determinants of savings are Y, G, T, the deficit (DEF=G-T), the interest rate (R), and other variables. For simplicity, the savings function, ignoring other variables, is linearized as:

(1) $S = \beta_0 + (1-\beta_1)(Y-\beta_2 G-\beta_3 T) + \beta_4 DEF + \beta_5 R.$

It is expected that β_1, β_2, β_3, β_4, and β_5 are all nonnegative. Under one version of the standard Keynesian approach, the coefficients would be $\beta_2=0$, $\beta_3=1$, and $\beta_4=0$. Then :

(2) $S = \beta_0 + (1-\beta_1)(Y-T) + \beta_5 R.$

The marginal propensity to consume from disposable income is β_1, where $0 < \beta_1 < 1$. Thus savings depends on disposable income. A tax cut affects savings, but savings increase by less than the amount of the tax cut. Returning to equilibrium requires a rise in the interest rate, as shown in Figure 1. A tax cut of $T_0 - T_1$ would cause the savings curve to shift to S' and the I + DEF curve to shift to (I + DEF)'. The interest rate thus rises to R_1.

The Ricardian equivalence theorem suggests that the coefficients are $\beta_2=1$, $\beta_3=0$, and $\beta_4=1$. Then:

(3) $S = \beta_0 + (1-\beta_1)(Y-G) + DEF + \beta_5 R$
$\quad = \beta_0 + (1-\beta_1) Y + \beta_1 G - T + \beta_5 R.$

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In this case, the tax cut leads savings to increase by exactly the amount of the tax cut (the savings curve in Figure 1 shifts to S") with no change in the interest rate R at equilibrium. The increase in DEF is offset by a rise in S.

The Ricardian equivalence theorem also has implications for the treatment of net wealth as a variable affecting macroeconomic variables such as consumption and investment. The debate in the monetary theory literature over inside money versus outside money (more generally, inside assets versus outside assets) suggests that private net wealth is the sum of the capital stock (K), some portion of the real money stock $\varphi(M/p)$, and some portion of the real value of government debt $\phi(B/rp)$, where $0 \leq \varphi \leq 1$ and $0 \leq \phi \leq 1$. In this framework, the Ricardian equivalence theorem requires that $\phi = 0$. Government debt is not part of the private sector's net wealth--changes in government debt can not affect private saving or consumption through a wealth effect.

Because many of the studies in the literature involve estimating consumption functions, equations (1), (2), and (3) must be rewritten in terms of consumption. It is assumed throughout this analysis that output (Y) is exogenously given, although this is clearly an oversimplification.[4] The budget constraints of individuals imply that at the aggregate level:

(4) $C = Y - T - S.$

Equation (1) may be rewritten eliminating the variable DEF and writing everything in terms of Y, G, T, and R:

(5) $S = \beta_0 + (1-\beta_1)Y - [\beta_2(1-\beta_1)-\beta_4]G - [\beta_3(1-\beta_1)+\beta_4]T + \beta_5 R.$

Consequently,

(6) $C = -\beta_0 + \beta_1 Y + [\beta_2(1-\beta_1)-\beta_4]G - [1-\beta_3(1-\beta_1)-\beta_4]T - \beta_5 R.$

In terms of the polar cases described earlier, the consumption function in the simple Keynesian approach ($\beta_2=0$, $\beta_3=1$, $\beta_4=0$) is:

(7) $C = -\beta_0 + \beta_1(Y-T) - \beta_5 R.$

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In the case of the Ricardian equivalence theorem ($\beta_2=1$, $\beta_3=0$, $\beta_4=1$), the consumption function is given by:

(8) $\quad C = -\beta_0 + \beta_1(Y-G) - \beta_5 R.$

The Keynesian hypothesis thus implies that consumption is a function of disposable income, while the Ricardian hypothesis is that consumption depends on income minus government spending. The two hypotheses give the same consumption function only when the government's budget is balanced.

Interpretations of Five Studies

For purposes of illustrating the interpretations made in the empirical literature, five studies chosen according to the frequency with which they are cited in the literature are reviewed. They are Kochin [18], Feldstein [12], Buiter and Tobin [9], Feldstein [13], and Kormendi [19]. All five studies estimate consumption functions and focus on the coefficients of deficit, debt, or Social Security wealth variables to test the Ricardian equivalence theorem. The type of nesting of alternative hypotheses described in equations (6) to (8) is performed in two of these studies, Kormendi [19] and Feldstein [13]. In describing the results of each study, the theoretical equation to be estimated is listed first, followed by the estimated equation which shows the specific proxy variable being used. For example, the theoretical equation for the Kochin study is (9a), and the estimated equation is (9b).

Consumption-function estimation in testing the RET is popular (as opposed to tests involving changes in interest rates or estimation of savings functions), probably because there is a large body of work on consumption-function estimation in general within the macroeconomic tradition. Given the model of the response of savings to changes in taxes under the Ricardian equivalence theorem, it is straightforward to see what happens to consumption. When the Ricardian equivalence theorem holds, a tax cut leads to an increase in savings equal in size to the amount of the tax cut. Consumption, therefore, is unchanged.[5] Consequently, many studies of the Ricardian equivalence theorem estimate consumption functions, with taxes and government debt as right-side variables affecting consumption. If the coefficients on the debt and taxes are zero, then the RET is accepted. Nonzero coefficients suggest that the Ricardian equivalence theorem does not hold.

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The first study to estimate a consumption function and test for the RET is Kochin [18]. He estimates a simple regression equation with consumption (C) as a function of disposable income (Y-T) and the federal deficit (G-T). He fits the equation:

$$(9a) \quad C = \delta_0 + \delta_1(Y-T) + \delta_2(G-T) + \delta_3 C_{-1},$$

$$(9b) \quad \Delta PC2RA = 2.88 + 0.392 \, \Delta YDRA - 0.109 \, \Delta FDEFRA$$
$$ (3.44) \quad (7.86) \quad\quad\quad (2.95)$$

$$+ \, 0.218 \, \Delta PC2RA_{-1},$$
$$(2.42)$$

$$\bar{R}^2 = .892, \, SE = 1.26,$$

on aggregate annual U.S. data, 1952-1971.[6] The variables are
PC2RA = real consumption expenditures on nondurables and services;
YDRA = real disposable income; and
FDEFRA = the real value of the federal deficit.

Kochin interprets the negative sign on the deficit variable to mean that some tax discounting occurs. He does not interpret the results in terms of the Ricardian equivalence theorem. The results indicate that an increased deficit arising from a tax cut increases consumption by 28 percent of the amount of the deficit,[7] thus causing savings to rise by the remaining 72 percent. A change in disposable income raises current consumption by about 40 percent of the change in income, with a long-run marginal propensity to consume of about 50 percent, which seems low compared to most estimates.

Kochin's negative sign on the deficit variable may arise due to the crowding-out effect of government spending, not tax discounting. As is clear from equations (6) through (8), a proper test is possible only by including government spending and taxes as separate variables, not by using the deficit variable by itself.[8]

Buiter and Tobin [9] suggest that if the Ricardian equivalence theorem holds, the coefficients on YDRA and FDEFRA in Kochin's equation (9) should be equal in magnitude and opposite in sign, as discussed in footnote 7. Thus Kochin provides evidence of nonneutrality of government deficits. Kochin's work is flawed, according to Buiter and Tobin, because of simultaneity in cyclical fluctuations of consumption, income, and the deficit. Fiscal policy

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moves the deficit countercyclically, so there is simultaneous-equations bias in equation (9).[9] Buiter and Tobin are critical of Kochin's proxy choices as well. They suggest that state and local government debt is important; private, not personal, disposable income should be used;[10] the proxy variable for consumption should include the imputed value of durables; and everything should be in per capita terms. Furthermore, equation (9) contains a constant term, implying a time trend in the undifferenced equation, that Kochin did not include when he ran his regression before differencing.[11]

Buiter and Tobin replicate Kochin's experiment with a different data set. They then perform sensitivity tests that show that Kochin's results are sensitive to the sample period chosen. Adding the years 1949-1951 and 1972-1976 to the sample period deprives the deficit of any explanatory power. Buiter and Tobin implement some of the suggestions made above on proxy choices. They find no support for debt neutrality, although the results are not robust due to the high degree of multicollinearity in all the independent variables. They estimate three different sets of regressions. All of the regressions are of consumption on national income and lagged consumption, plus fiscal variables. One regression includes net taxes (taxes minus transfers) and the government deficit, a second includes just government purchases of goods and services, while the third is identical to the second but constrains the coefficients on government purchases and national income to be identical. In all cases, the deficit variable and the government purchases variable are found to be statistically insignificant.

Equation (10) shows their regression of consumption (C) on national income (Y) and government purchases of goods and services (G):

(10a) $C = \delta_0 + \delta_1 Y + \delta_2 G + \delta_3 C_{-1}$,

(10b) PCERP = -156.2 + 0.352 NIRP - 0.408 GSRP
            (0.9)   (4.0)   (0.8)

            + 0.682 PCERP$_{-1}$,
              (6.6)

$\bar{R}^2 = .994$, SE = 40.63, DW = 1.51.

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The regression is run on annual data for 1949-1976 in real per capita terms. PCERP is personal consumption expenditures, NIRP is national income, and GSRP is total government purchases of goods and services.

Because the coefficient on GSRP is statistically insignificant, Buiter and Tobin claim that the Ricardian equivalence theorem is rejected. They observe that there is a high degree of multicollinearity between NIRP and GSRP. Consequently, they run another regression in which government purchases are subtracted from national income to form a new variable (Y-G):

(11a) $C = \delta_0 + \delta_1(Y\text{-}G) + \delta_2 C_{-1}$,

(11b) PCERP = -135.7 + 0.345 NIGSRP + 0.673 PCERP$_{-1}$,
$\qquad\qquad\quad$ (3.0)$\quad$ (5.1)$\qquad\qquad$ (9.0)

$\bar{R}^2 = .994$, SE = 39.8, DW = 1.50,

where

NIGSRP = NIRP-GSRP.

Buiter and Tobin compare this regression to one that uses personal disposable income (Y-T) instead of national income as a regressor:

(12a) $C = \delta_0 + \delta_1(Y\text{-}T)$,

(12b) PCERP = 123.4 + 0.875 YDRP,
$\qquad\qquad\quad$ (4.5)$\quad$ (100.4)

$\bar{R}^2 = .997$, SE = 27.0, DW = 1.47.

Equations (11) and (12) resemble equations (7) and (8) above, except that they are missing the interest rate as an explanatory variable. Buiter and Tobin claim that a comparison of equations (11) and (12) supports Keynesian theory, because equation (12) has a lower standard error than does equation (11). It is difficult to deny the close relationship between consumption and disposable income. Given the differences between national income and personal disposable income, however, it is difficult to view this as evidence against the Ricardian equivalence theorem. It

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may be preferable to examine a regression in which the tax variable enters separately, so that its significance may be tested.

Kormendi [19] provides the sharpest test to date of the Ricardian equivalence theorem. Among various specifications that lend empirical support to the RET, a key result comes from an equation that includes wealth (W), transfer payments (TR), government debt (D), taxes (T), retained earnings (RE), and government net interest (GI):

$$(13a) \quad C = \delta_0 + \delta_1 Y + \delta_2 Y_{-1} + \delta_3 G + \delta_4 W + \delta_5 TR + \delta_6 D + \delta_7 T + \delta_8 RE + \delta_9 GI,$$

$$(13b) \quad \Delta PC1RP = INT + \underset{(7.3)}{0.29} \ \Delta NNPRP + \underset{(3.3)}{0.07} \ \Delta NNPRP_{-1}$$

$$- \underset{(12.8)}{0.23} \ \Delta GSRP + \underset{(3.0)}{0.025} \ \Delta WRP$$

$$+ \underset{(5.6)}{0.83} \ \Delta TRRP - \underset{(2.9)}{0.55} \ \Delta GBRP$$

$$+ \underset{(0.9)}{0.07} \ \Delta TXRP + \underset{(0.9)}{0.10} \ \Delta RERP$$

$$+ \underset{(1.3)}{1.15} \ \Delta GINTRP,$$

$$R^2 = .911, \ SE = .0175.$$

This equation is estimated in first-difference form including an intercept (INT) term, on annual U.S. data for 1931-1976. The variables (all in real per capita terms) are

PC1RP = consumption on nondurables and services, including imputed services from durables;
NNPRP = net national product;
GSRP = government spending on goods and services;
WRP = national wealth (excluding the value of government debt);
TRRP = transfer payments;

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GBRP = market value of all government debt;
TXRP = total government receipts;
RERP = retained earnings;
GINTRP = government net interest.

The inclusion of the war years in the sample period has a strong influence on the t-statistics for government spending and government debt. Kormendi shows, however, that the coefficients on taxes (TXRP), retained earnings (RERP), and government net interest (GINTRP) remain statistically insignificant whether the war years are included or not.[12] Consequently, these variables are eliminated from the analysis, and a new regression is run excluding the war years:

(14a) $C = \delta_0 + \delta_1 Y + \delta_2 Y_{-1} + \delta_3 G + \delta_4 W + \delta_5 TR + \delta_6 D,$

(14b) $\Delta PC1RP = INT + 0.33\ \Delta NNPRP + 0.05\ \Delta NNPRP_{-1}$
$$\qquad\qquad\qquad (14.1)\qquad\qquad (2.2)$$

$$- 0.21\ \Delta GSRP + 0.032\ \Delta WRP + 0.74\ \Delta TRRP$$
$$\quad (3.5)\qquad\qquad (3.5)\qquad\qquad (3.5)$$

$$- 0.032\ \Delta GBRP,$$
$$\quad (1.6)$$

$R^2 = .910$, SE = .0178, DW = 1.6.

This equation is estimated for the period 1931-1940/1947-1976.

If debt neutrality holds, the coefficient on government debt (GBRP) should be zero, and the coefficient on government spending (GSRP) should be negative. The regression results in (14) thus support the Ricardian equivalence theorem. Kormendi claims that the results are robust to including the war years, using alternative estimation techniques, and using disposable income instead of net national product as an independent variable. Kormendi first-differences the estimated equation to correct for possible nonstationarity.

Kormendi's results have been criticized by Modigliani and Sterling [23] and subjected to sensitivity tests by Barth, Iden, and Russek [7]. The sensitivity analysis of Barth, Iden, and Russek suggests only minor problems with Kormendi's specification, but Modigliani-Sterling are far more critical. They suggest that the long-run marginal propensity to

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consume from equation (14) is lower than expected, about .4 instead of the normal range of .7 to .9. They also find fault with several of Kormendi's proxy choices and methods of dynamic modeling. In response, Kormendi and Meguire [20] suggest that Modigliani-Sterling do not nest the alternative hypotheses, and that their empirical results are questionable due to nonstationarity in their data.

Because the Social Security system in the United States is an unfunded, pay-as-you-go arrangement, it has effects similar to government debt. Thus several studies have examined the Ricardian equivalence theorem by seeing if changes in the implicit debt of the Social Security system affect consumption spending. The first and most widely known of these studies is by Feldstein [12]. He develops a measure of the present value of future benefits that individuals expect to receive from the Social Security system. A consumption function is estimated including this measure of Social Security wealth (SSW) as a regressor, along with wealth (W) and retained earnings (RE). On U.S. annual data in real per capita terms for 1929-1940/1947-1971, the result is:

(15a) $C = \delta_0 + \delta_1(Y-T) + \delta_2(Y-T)_{-1} + \delta_3 RE + \delta_4 W + \delta_5 SSW,$

(15b) $PCERP = 228 + 0.530\ YDRP + 0.120\ YDRP_{-1}$
$(7.4)\quad(11.3)(3.4)$

$+ 0.356\ RERP + 0.014\ WRP$
$(4.8)(3.5)$

$+ 0.021\ SSWRP,$
(3.5)

DW = 1.82, SE = 11.0,

where

PCERP = personal consumption expenditure;
YDRP = personal disposable income;
RERP = retained earnings;
WRP = the market value of household net worth; and
SSWRP = a gross measure of Social Security wealth.

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The significant coefficient on the Social Security wealth variable suggests that the Ricardian equivalence theorem does not hold for the government's Social Security debt. Surprisingly, the coefficient on Social Security wealth exceeds that on wealth. This may be because the wealth measure used by Feldstein includes the value of government debt. The results also indicate that savings would be 50 percent higher in 1971 if the Social Security system did not exist.

Feldstein's results have been criticized severely. Most importantly, Leimer and Lesnoy [22] find that a computational error in Feldstein's creation of the Social Security wealth variable is important to the results. When the error (which Feldstein acknowledged) is corrected, Social Security wealth becomes insignificant in the consumption regression. Leimer and Lesnoy also find that Feldstein's results are sensitive to the sample period chosen. Further, they question some of the assumptions that go into the creation of the Social Security wealth variable, because such a variable requires an explicit formulation of how persons form expectations about future benefits under the system.

Feldstein [14] suggests that the sensitivity of the results to the sampling period is due to the significant change in benefits that went into effect in 1972. He reruns his original regression for a sample ending in 1971 (including the corrected variable for Social Security wealth) and finds support for his original results (although the magnitude of the impact on saving is not the same).

Feldstein's [12] result rejected the Ricardian equivalence theorem. If the RET holds, Social Security wealth should have no effect on consumption because it is a pure debt. The regression in Feldstein, however, does not deal with other forms of government debt and is thus not a strong test of the RET. More recently, Feldstein [13] attempts a more explicit test of the Ricardian equivalence theorem. He adds government spending (G), tax (T), transfer (TR), and debt (D) variables to the consumption equation with the following results:

(16a) $C = \delta_0 + \delta_1(Y\text{-}T) + \delta_2(Y\text{-}T)_{-1} + \delta_3 W + \delta_4 SSW + \delta_5 G + \delta_6 T + \delta_7 TR + \delta_8 D,$

(16b) $PCERP = -0.413 + 0.582\ YDRP + 0.053\ YDRP_{-1}$
$\qquad\qquad\ \ (0.5)\quad\ (2.9)\qquad\quad\ (0.4)$

$\qquad\qquad + 0.102\ WRP + 0.064\ SSWRP$
$\qquad\qquad\ \ (1.0)\qquad\quad\ (0.8)$

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$$+ 0.927 \text{ GSRP} - 1.734 \text{ TXRP}$$
$$(0.8) \qquad\qquad (0.8)$$

$$+ 1.256 \text{ TRRP} + 0.175 \text{ GBRP},$$
$$(1.0) \qquad\qquad (1.0)$$

SE = .0713, DW = 1.76,

where

PCERP = personal consumption expenditure;
YDRP = personal disposable income;
WRP = the market value of private net wealth (including government
    debt);
SSWRP = Social Security wealth;
GSRP = government purchases of goods and services;
TXRP = total government receipts;
TRRP = government transfers to individuals; and
GBRP = government debt.

The equation is estimated on annual U.S. data for 1930-1940/1947-1977, with all variables in real per capita terms. Because Feldstein feels that there are simultaneity problems with the tax variable (TXRP), he uses TXRP_{-1} as an instrumental variable for TXRP. Because of the apparent problem of multicollinearity, Feldstein drops the government debt (GBRP) variable and reruns the equation:

$$(17) \quad \text{PCERP} = 0.207 + 0.738 \text{ YDRP} + 0.060 \text{ YDRP}_{-1}$$
$$(2.2) \quad (9.5) \qquad\qquad (1.3)$$

$$+ 0.009 \text{ WRP} + 0.014 \text{ SSWRP}$$
$$(1.3) \qquad\qquad (1.0)$$

$$- 0.027 \text{ GSRP} - 0.047 \text{ TXRP}$$
$$(0.2) \qquad\qquad (0.2)$$

$$+ 0.135 \text{ TRRP},$$
$$(1.5)$$

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SE = .0218, DW = 1.64

Feldstein claims that this equation provides strong evidence against the Ricardian equivalence theorem. The coefficients on government spending (GSRP) and taxes (TXRP) are small and statistically insignificant, while the coefficients on transfers (TRRP) and Social Security wealth (SSWRP) are positive.

Feldstein's willingness to cite this regression as evidence against the Ricardian equivalence theorem seems odd. The statistical insignificance of every variable except disposable income (YDRP) is indicative of serious multicollinearity, which Feldstein recognized in the earlier equation. He also thinks that the positive coefficients found for Social Security wealth (SSWRP) and transfers (TRRP) are important, despite their lack of statistical significance.

Interpretations in Terms of Simultaneous Equations

Economic theory suggests that government debt is a burden on future generations only if it raises interest rates. The five studies under examination fail to deal with interest rates in their tests of the Ricardian equivalence theorem. This section examines whether interest rates are important determinants of savings and investment and how the interest rate adjusts to clear the market for funds. The interpretations of the coefficients in the model differ from those of a single-equation system.

A simple investment function is posited:

$$(18) \quad I = \alpha_0 + \alpha_1 Y - \alpha_5 R.$$

α_1 and α_5 are expected to be nonnegative. This simple investment function is designed to match economic theory; investment falls when the interest rate rises, but rises with output. Market clearing in the market for funds now requires:

$$(19) \quad S = I + DEF.$$

The interest rate adjusts to clear the market. The reduced form for the interest rate is:

$$(20) \quad R = \{(\alpha_0 - \beta_0) - (1 - \alpha_1 - \beta_1)Y + [1 + (1 - \beta_1)\beta_2 - \beta_4]G +$$

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$[(1-\beta_1)\beta_3 + \beta_4 - 1]T\}/(\alpha_5 + \beta_5).$

Under the standard Keynesian approach, with $\beta_2=0$, $\beta_3=1$, $\beta_4=0$, the interest rate is:

(21) $R = \{(\alpha_0 - \beta_0) - (1 - \alpha_1 - \beta_1)Y + G - \beta_1 T\}/(\alpha_5 + \beta_5)$

Under the Ricardian equivalence theorem, the interest rate is (where $\beta_2=1$, $\beta_3=0$, and $\beta_4=1$):

(22) $R = \{(\alpha_0 - \beta_0) - (1 - \alpha_1 - \beta_1)Y + (1 - \beta_1)G\}/(\alpha_5 + \beta_5).$

In the case of a tax cut, the rise in the interest rate is given by $-dR/dT = \beta_1/(\alpha_5 + \beta_5) > 0$ for the standard Keynesian approach, and $-dR/dT = 0$ under the Ricardian equivalence theorem. Note, however, that there is no difference between the two approaches in the case of a balanced budget increase in government spending ($dG=dT$), when $dR/dT = (1 - \beta_1)/(\alpha_5 + \beta_5)$.

The reduced form for the interest rate is used to find the reduced form for consumption:

(23) $C = \{-(\alpha_0 \beta_5 + \alpha_5 \beta_0) + [(1-\alpha_1)\beta_5 + \alpha_5 \beta_1]Y + [\alpha_5[(1-\beta_1)\beta_2 - \beta_4]$

$\beta_5]G - \alpha_5[1-(1-\beta_1)\beta_3 - \beta_4]T\}/(\alpha_5 + \beta_5).$

Under the standard Keynesian approach, this is:

(24) $C = \{-(\alpha_0 \beta_5 + \alpha_5 \beta_0) + [(1-\alpha_1)\beta_5 + \alpha_5 \beta_1]Y - \beta_5 G$
$- \alpha_5 \beta_1 T\}/(\alpha_5 + \beta_5),$

while under the Ricardian equivalence theorem it is:

(25) $C = \{-(\alpha_0 \beta_5 + \alpha_5 \beta_0) + [(1-\alpha_1)\beta_5 + \alpha_5 \beta_1]Y -$
$(\alpha_5 \beta_1 + \beta_5)G\}/(\alpha_5 + \beta_5).$

Now the coefficients on G and T under the two approaches, abbreviated as SKA and RET, for both the nonreduced form given by equation (6) and the reduced form of equation (23) are examined.

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Coefficients on:	Nonreduced form (6)	Reduced form (23)
G (SKA)	0	$-\beta_5/(\alpha_5+\beta_5) < 0$
G (RET)	$-\beta_1 < 0$	$-(\alpha_5\beta_1+\beta_5)/(\alpha_5+\beta_5) < 0$
T (SKA)	$-\beta_1 < 0$	$-\alpha_5\beta_1/(\alpha_5+\beta_5) < 0$
T (RET)	0	0

The only coefficient that remains unchanged in going from the nonreduced form to the reduced form is the coefficient on T under the Ricardian equivalence theorem, which remains at zero in both equations.

Given these results, the interpretations (that assume that a structural equation has been estimated) made by the authors of the five studies in question are valid only if the coefficient (β_5) on the interest rate variable in the consumption function is zero.[13] Their results depend on the absence of an interest rate effect on savings. On the other hand, if β_5 is nonzero, then what they have estimated is a reduced form for consumption such as equation (23) with quite different implications.

Equation (24) has empirical implications for those who believe in the standard Keynesian approach. Buiter and Tobin, for example, regress consumption on disposable income, arguing that this equation is consistent with Keynesian theory and is empirically superior to other equations for consumption. As equation (24) shows, this assertion is false if interest rates affect consumption ($\beta_5 \neq 0$). Government spending ought to be an included variable and the coefficients on income and taxes ought to be different because the equation is a reduced-form equation, not a structural equation.

Replications, Sensitivity Testing, and Simultaneous-Equations Estimation

Given these theoretical results for the simultaneous-equations system, how would the empirical results of the five studies mentioned above be affected? As none of the studies includes an interest rate variable, their results cannot be compared directly. Therefore, this paper attempts to replicate each study using a master data set for 1929-1976. Next each is tested for sensitivity to the sample period chosen. Then the interest rate is included as a variable in the consumption function to

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see if it seems to be an important omitted variable.[14] Finally, the consumption function and an investment function are estimated simultaneously. Tables 2 through 8 show the results.

Kochin

Replications of Kochin's results are shown in Table 2. The table shows five results: (1) the first column (ORIG) shows Kochin's original results; (2) the REPL column attempts to replicate Kochin's results; (3) the 47-83 column extends the time period from 1952-1971 to 1947-1983; (4) the TB3R column adds the interest rate variable TB3R to the equation; and (5) the 2SLS column estimates the consumption function simultaneously with an investment function in which the interest rate is treated as endogenous.

The replication is similar to Kochin's original regression. When the sample period is extended to 1947-1983, however, the results change significantly. The federal deficit variable becomes statistically insignificant. The Durbin-Watson statistic for the regression shows problems with the regression. But these problems disappear with the introduction of the interest rate variable (TB3R) into the regression. This suggests that the Durbin-Watson statistic in the earlier regression was signaling the presence of an omitted variable, not autocorrelation. The two equation approach (2SLS) confirms this result. The federal deficit lacks significance in the regression.

Buiter and Tobin

Tables 3 and 4 show replications of the Buiter and Tobin results. Table 3 shows that it is difficult to resist the notion that personal consumption is related closely to disposable personal income. Replication results are similar to the original. The addition of the interest rate as a regressor does not seem to add anything. The replication using national income minus government purchases (NIGSRP) shown in Table 4 is fairly close to the original. But now the interest rate variable plays a significant role in the single equation, although it is somewhat weaker in the simultaneous system.

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Kormendi

Kormendi's results are replicated in Table 5. The data set differs from Kormendi's original data set only in the wealth variable. Kormendi runs the regressions in first differences in response to perceived nonstationarity of the variables in levels. Table 5 shows that the replication is similar to the original study but significantly different for some variables, due solely to the alternate wealth proxy choice. Variation in the sample period (see the column for the 1947-1976 regression) primarily affects the coefficients on government purchases and government debt. Adding the interest rate to the regression, either using ordinary least squares or the simultaneous-equations approach, has little impact.

There may be a small problem with these regressions as a result of the construction of the dependent variable PC1RP. Kormendi attempts to construct a variable that incorporates consumption of durables. The consumption variable (PC1RP) thus adds consumption of nondurables (CNDRP), consumption of services (CSRP), and 0.3 x the stock of durable consumer goods (DURRP). It may be that the arbitrary fixed coefficient of 0.3 on the durable stock induces autocorrelation in the PC1RP regressions, especially because the regressions of Feldstein using personal consumption expenditures (PCERP) regressed on many of the same right side variables, do not exhibit autocorrelation in the residuals.

Kormendi's proxy variable for wealth excludes the value of government debt, so the test of the Ricardian equivalence theorem is whether the coefficient on the government debt variable (GBRP) is zero. The proxy variable for wealth used in the replications is that of Feldstein [13], which includes the value of government debt. Under the Ricardian equivalence theorem, the coefficient of GBRP ought to be negative and equal in magnitude to the coefficient on the wealth variable. Under the standard Keynesian approach the coefficient on GBRP ought to be zero. The imprecision of the estimates, as witnessed by the low t-statistics on WRP and GBRP, prevents a robust conclusion. It should be noted, however, that the coefficients on these variables are fairly stable across the alternative specifications given in Table 5.

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Feldstein [12]

Table 6 shows the replication of Feldstein's results. The first two columns show that the results are replicated fairly closely, but regressions over the sample period 1947-1971 and 1947-1976 show dramatic differences in the results. The coefficients on the wealth variable (WRP) and Social Security wealth variable (SSWRP) are sensitive to the sample period and are highly unstable across the alternative specifications given in Table 6. Adding the interest rate variable (TB3R) yields interesting results. In the ordinary least squares regression adding the interest rate variable has some impact on the wealth variable, which does not seem surprising.

When the simultaneous-equations estimate is run, however, the regression falls apart. The standard error increases nearly tenfold. The major reason for this result is telling: in the second-stage of the two stage least squares procedure, the interest rate variable is the most important variable in the regression. It is estimated imprecisely in the first stage, however, so the estimated values of consumption differ significantly from the actual values. This suggests that the interest rate is an important determinant of consumption, but that there may be changes needed in the structural equations (omitted variables or functional form).

Feldstein [13]

Table 7 shows the replication of Feldstein's results, including government debt (GBRP) as an explanatory variable. Replication of the original regression does not work well when the government debt (GBRP) variable is included, but comes close for most variables when GBRP is excluded.   This suggests that the proxy variable for government debt used by Feldstein is significantly different from the one used in this study.   To compare the results with Feldstein's instrumental variables estimation, but also to allow the simultaneous-equations estimation later, the estimation is done using two stage least squares. Lagged government revenue (TXRPL) is used as an instrument for current TXRP.

Adding the interest rate variable (TB3R) to the single equation estimation causes little change. The two equation estimation looks quite different, however. The government revenue (TXRP) coefficient is positive and close to the coefficient on disposable income (YDRP),

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lending some support to the Ricardian equivalence theorem.[15] Transfer payments and Social Security wealth are insignificant, while government purchases crowd out consumption. Because the wealth variable includes the value of government debt, the RET suggests that the coefficient on government debt (GBRP) ought to be negative and of equal magnitude to the coefficient on wealth (WRP). As the government debt variable is positive and marginally significant, there is some evidence against the RET.

Investment Equations

Table 8 shows the estimated investment equations for the two-stage least squares estimations. The structural equation for investment is a simple one:

$$(26) \quad GI_t = \alpha_0 + \alpha_1 NNP_t + \alpha_2 GI_{t-1} - \alpha_3 TB3R,$$

where

GI = gross investment.

α_1, α_2, and α_3 are expected to be nonnegative. The estimation does not work well when used with the consumption equations of Kochin and Buiter and Tobin. In both cases, low Durbin-Watson statistics are indicative of some problems in the regression structure. Gross investment, however, is estimated well for the Feldstein [12] and Feldstein [13] equations. The interest rate has a negative and statistically significant coefficient, and the other signs are as expected.

Summary and Conclusions

This paper attempts to show that existing single equation estimation of consumption functions may be inadequate for testing the Ricardian equivalence theorem. In a simple macroeconomic framework, it is demonstrated that interpreting estimated consumption functions as structural equations may be misleading if interest rates, consumption, and investment are determined simultaneously. To show the importance of this result empirically, five studies are replicated and reestimated using a two-equation system.

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The reestimation of Kochin's results shows the importance of the interest rate as a variable in the consumption function. The consumption equation is seriously misspecified, however, because it is in aggregate rather than per capita terms and because it includes only the federal deficit rather than the total government deficit as a regressor.

Buiter and Tobin demonstrate the close relationship between disposable personal income and personal consumption expenditures. But their regression alone is an inadequate test of the Ricardian equivalence theorem, and there is some evidence of omitted variables (such as the interest rate and other variables included by Feldstein [12] and Feldstein [13].)

Feldstein tests the effects on consumption of Social Security wealth. His finding of a significant relationship is not confirmed by the replications, which show great sensitivity to the sample period chosen. The interest rate seems to be an important explanatory variable for consumption.

The sharpest tests of the Ricardian equivalence theorem come from using the method of nesting alternative hypotheses as is done by Kormendi and Feldstein. Kormendi finds support for the Ricardian equivalence theorem, and his results hold up well to sensitivity analysis. The results are somewhat sensitive to differences in the proxy variables used as well as the sample period.

The presence of multicollinearity clouds the results of Feldstein. Feldstein finds evidence against the RET, but reestimating his equations does not support that position fully. The two equation estimate including the interest rate as a regressor yields different results from the single equation estimation that omits the interest rate variable.

The estimated investment equations work well. The coefficient on the interest rate is significant and negative in many of the regressions. Although this paper devotes little effort to the specification of this equation, it is important in the estimation of consumption. In a simultaneous-equations estimation, structural misspecification in one equation may affect the other equation adversely. There is some evidence of this in the Kochin and Buiter and Tobin reestimations.

Overall, the evidence on the Ricardian equivalence theorem is mixed. The Feldstein-Kormendi nesting approach offers the greatest test of the hypothesis, but the results are unclear. The evidence suggests strongly that the interest rate is an important variable affecting consumption, and that the two equation approach holds promise.

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There are other aspects to testing the Ricardian equivalence theorem that have been ignored in this paper. Many variables that have been treated as exogenous are not; a model that specifies a complete macroeconomic structure may be needed for an adequate test of the RET. In particular, modeling reaction functions for monetary and fiscal policy may be necessary. The Lucas critique applies here if policy regimes have changed significantly over time. This would explain the sample period sensitivity of the results. The distinction between a Ricardian regime in which current debt is repaid by future taxes and a non-Ricardian regime in which debt is rolled over forever is crucial. Further, more work on business cycle effects and proxy choices seems warranted.

The key question is whether the interest rate belongs in the consumption function. Macroeconomic theory strongly suggests that it does. Gylfason [16] provides some empirical evidence showing the importance of the interest rate for consumption. This paper demonstrates not only that the interest rate is important, but also that a proper investigation of the effect of government debt on consumption and interest rates requires a simultaneous-equations approach.

Endnotes

*Thanks to M. Kevin McGee and referees for useful comments and suggestions on an earlier draft. Thanks also to Philip Meguire and Roger C. Kormendi for access to their original data and helpful discussion of preliminary replications of Kormendi's work.

1. This is true in a closed economy. In an open economy, of course, borrowing from abroad may lead to a burden on future generations if higher taxes are imposed in the future to repay the foreign debt.

2. The fragile nature of empirical results concerning the effects of government budget deficits on interest rates is demonstrated by Barth, Iden, and Russek [5]. For other criticisms of this literature, see Bernheim [8].

3. In the GNP accounting framework, ignoring the foreign sector, this comes from the goods market clearing condition C+I+G=C+S+T, which can be rewritten as I+DEF=S where DEF=G-T.

4. Although changes in the interest rate may have no contemporaneous effect on output, they must have some future effect if the government debt is to have any burden on future generations.

5. As consumption (C) equals Y-T-S, consumption is unaffected because the fall in T is exactly offset by a rise in S.

6. In every empirical equation in this paper, the numbers in parentheses beneath estimated coefficients are the absolute values of t-statistics, DW is the Durbin-Watson statistic, and SE is the standard error of estimate. Time subscripts are omitted, with a subscript of "-1" meaning the value of the variable at time t-1. Unless specified otherwise, statistical tests are performed at the 5 percent level.

7. This result is clear from looking at the equation: $C = \alpha(Y-T)+\beta(G-T) = \alpha Y - (\alpha+\beta)T + \beta G$. Thus the immediate impact of a tax change is found by adding the coefficients on disposable income and the deficit. Notice, however, that this form of estimation is unnecessarily restrictive, as it imposes an implicit constraint on the coefficients on Y, T, and G.

8. This point also is discussed by Barth, Iden, and Russek [5].

9. This also may be why Kochin found a low Durbin-Watson value in his nondifferenced equation. It seems likely that the problem is specification error, not autocorrelation.

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10. Private disposable income includes retained earnings of the corporate sector, but personal disposable income does not.

11. The (implicit) time trend in equation (9) which is missing from Kochin's nondifferenced specification probably explains the significantly different coefficient estimates between the differenced and nondifferenced versions. This is not surprising with a time series dataset in which all variables are growing.

12. See Kormendi [19], Tables 4 and 5. Feldstein and Elmendorf [15] refute this, however, arguing that the war years have a big impact on the estimated regression.

13. Equation (23) is identical to equation (6) when $\beta_5 = 0$.

14. The OLS regressions that include the interest rate as a variable eliminate the omitted variables bias, but contain simultaneous-equations bias. This intermediate step shows the importance of each of these biases.

15. As Feldstein uses as regressors Y-T and T, the coefficient on Y-T must be subtracted from the coefficient on T to find the overall coefficient on T. Thus if the coefficients on Y-T and T are close together, the implicit coefficient showing the total effect of T on C is close to zero, as suggested by the Ricardian equivalence theorem.

16. Kormendi's original wealth variable excludes the value of government debt, while the data used in the replication include the value of government debt.

17. Feldstein reports his sample period as running through 1977, but the data he reports run only through 1976. Thus the replication and simultaneous-equation estimation only go to 1976.

18. For Kochin, the estimated investment function is GIRA as a function of NNPRA, GIRAL, and TB3R. For all others, GIRP is a function of NNPRP, GIRPL, and TB3R.

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References

1. Barro, Robert J., "Are Government Bonds Net Wealth?" *Journal of Political Economy*, 82 (Nov./Dec. 1974), pp. 1095-1117.

2. _____, "Reply to Feldstein and Buchanan," *Journal of Political Economy*, 84 (April 1976), pp. 343-349.

3. _____, "Public Debt and Taxes," in Michael J. Boskin (ed.) *Federal Tax Reform* (San Francisco: Institute for Contemporary Studies, 1978a).

4. _____, *The Impact of Social Security on Private Saving* (Washington, D. C.: American Enterprise Institute, 1978b).

5. Barth, James, R., George Iden, and Frank S. Russek, "Do Federal Deficits Really Matter?" *Contemporary Policy Issues*, 3 (Fall 1984-1985), pp. 79-95.

6. _____, _____, and _____, "Federal Borrowing and Short-Term Interest Rates: Comment," *Southern Economic Journal*, 52 (October 1985), pp. 554-559.

7. _____, _____, and _____, "Government Debt, Government Spending, and Private Sector Behavior: Some Additional Results," *American Economic Review*, 76 (December 1986), pp. 1158-1167.

8. Bernheim, B. Douglas, "Ricardian Equivalence: An Evaluation of Theory and Evidence," *NBER Macroeconomics Annual 1987* (Cambridge, Massachusetts: MIT Press, 1987), pp. 263-304.

9. Buiter, Willem H. and Tobin, James, "Debt Neutrality: A Brief Review of Doctrine and Evidence," in George M. von Furstenberg (ed.) *Social Security vs. Private Saving* (Cambridge: Harper and Row, 1979), pp. 39-63.

10. Darby, Michael R., *The Effects of Social Security on Income and the Capital Stock* (Washington, D.C.: American Enterprise Institute, 1979).

11. Evans, Paul, "Do Large Deficits Produce High Interest Rates?" *American Economic Review*, 75 (March 1985), pp. 68-87.

12. Feldstein, Martin, "Social Security, Induced Retirement, and Aggregate Capital Accumulation," *Journal of Political Economy*, 82 (Sept./Oct. 1974), pp. 905-926.

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13. _____, "Government Deficits and Aggregate Demand," *Journal of Monetary Economics,* 9 (January 1982a), pp. 1-20.

14. _____, "Social Security and Private Saving: Reply," *Journal of Political Economy,* 90 (June 1982b), pp. 630-642.

15. Feldstein, Martin and Douglas W. Elmendorf, "Taxes, Budget Deficits and Consumer Spending: Some New Evidence," National Bureau of Economic Research, working paper no. 2355 (August 1987).

16. Gylfason, Thorvaldur, "Interest Rates, Inflation, and the Aggregate Consumption Function," *Review of Economics and Statistics,* 63 (May 1981), pp. 233-245.

17. Holcombe, Randall G., John D. Jackson, and Ashgar Zardkoohi, "The National Debt Controversy," *Kyklos,* 34 (1981), pp. 186-202.

18. Kochin, Levis A., "Are Future Taxes Anticipated by Consumers?" *Journal of Money, Credit and Banking,* 6 (August 1974), pp. 385-394.

19. Kormendi, Roger C., "Government Debt, Government Spending, and Private Sector Behavior," *American Economic Review,* 73 (December 1983), pp. 994-1010.

20. Kormendi, Roger C. and Philip Meguire, "Government Debt, Government Spending, and Private Sector Behavior: Reply," *American Economic Review,* 76 (December 1986), pp. 1180-1187.

21. Koskela, Erkki and Matti Viren, "Social Security and Household Saving in an International Cross Section, " *American Economic Review,* 73 (March 1983), pp. 212-217.

22. Leimer, Dean R. and Selig D. Lesnoy, "Social Security and Private Saving: New Time Series Evidence," *Journal of Political Economy,* 90 (June 1982), pp. 606-629.

23. Modigliani, Franco and Arlie Sterling, "Government Debt, Government Spending, and Private Sector Behavior: A Comment," *American Economic Review,* 76 (December 1986), pp. 1168-1179.

24. Munnell, Alicia H., "The Impact of Social Security on Personal Savings," *National Tax Journal,* 27 (December 1974a), pp. 553-567.

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25. _____, *The Effects of Social Security on Personal Saving* (Cambridge: Ballinger, 1974b).

26. Reid, Bradford G., "Aggregate Consumption and Deficit Financing: An Attempt to Separate Permanent from Transitory Effects," *Economic Inquiry,* 23 (July 1985), pp. 475-486.

27. Seater, John J., "The Market Value of Outstanding Government Debt, 1919-1975," *Journal of Monetary Economics,* 8 (July 1981), pp. 85-101.

28. Seater, John J. and Robert S. Mariano, "New Tests of the Life Cycle and Tax Discounting Hypothesis," *Journal of Monetary Economics,* 15 (March 1985), pp. 195-215.

29. Tanner, J. Ernest, "Empirical Evidence on the Short-Run Real Balance Effect in Canada," *Journal of Money, Credit and Banking,* 2 (November 1970), pp. 473-485.

30. _____, "An Empirical Investigation of Tax Discounting," *Journal of Money, Credit and Banking,* 11 (May 1979), pp. 214-218.

31. U.S. Department of Commerce, Bureau of Economic Analysis, *The National Income and Product Accounts of the United States, 1929-1976 Statistical Tables* (Washington D.C.: U.S. Government Printing Office, 1981).

32. _____, *Survey of Current Business,* various issues (see data appendix).

33. _____, *Fixed Reproducible Tangible Wealth in the U.S., 1925-1979* (Washington D.C.: U.S. Government Printing Office, 1982).

34. _____, *Business Statistics,* various issues (see data appendix).

35. Yawitz, Jess B. and Laurence H. Meyer, "An Empirical Investigation of the Extent of Tax Discounting," *Journal of Money, Credit and Banking,* 8 (May 1976), pp. 247-254.

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Table 1

Summary Evidence on the Effects of Government Debt,
Deficits, and Social Security Wealth
on the Ricardian Equivalence Theorem (RET)

	Supports RET			Rejects RET		
	Deficit	Debt	SSW	Deficit	Debt	SSW
1. Tanner [29]		X				
2. Kochin [18]				X		
3. Munnell [24, 25]						X
4. Feldstein [12]						X
5. Yawitz-Meyer [35]					X	
6. Barro [4]			X			
7. Darby [10]						X
8. Buiter-Tobin [9]				X		
9. Tanner [30]		X				
10. Holcombe-Jackson-Zardkoohi [17]					X	
11. Feldstein [13]				X		

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Table 1 (continued)
Summary Evidence on the Effects of Government Debt,
Deficits, and Social Security Wealth
on the Ricardian Equivalence Theorem (RET)

	Supports RET			Rejects RET		
	Deficit	Debt	SSW	Deficit	Debt	SSW
12. Feldstein [14]						X
13. Leimer-Lesnoy [22]			X			
14. Kormendi [19]	X	X				
15. Koskela-Viren [21]			X			
16. Evans [11]	X					
17. Seater-Mariano [28]		X				
18. Reid [26]				X		
19. Modigliani-Sterling [23]				X	X	

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Table 2
Kochin- Levels
Dependent Variable PC2RA

$$C = \delta_0 + \delta_1(Y-T) + \delta_2(G-T) + \delta_3 C_{-1} + \delta_4 R$$

	ORIG	REPL	47-83	TB3R	2SLS
INT	5.56 (1.8)	8.94 (1.7)	16.0 (3.8)	16.0 (4.0)	20.1 (3.4)
YDRA	0.283 (3.8)	0.249 (3.2)	0.328 (5.6)	0.266 (4.8)	0.276 (4.2)
FDEFRA	-0.224 (2.6)	-0.214 (2.7)	0.0322 (0.6)	-0.0471 (0.7)	0.0496 (0.4)
PC2RAL	0.643 (5.1)	0.692 (6.2)	0.568 (6.8)	0.643 (8.0)	0.615 (6.3)
TB3R	--	--	--	3.27 (4.1)	5.16 (2.7)
Period	52-71	52-71	47-83	52-71	52-71

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Table 2 (continued)
Kochin- Levels
Dependent Variable PC2RA

$$C = \delta_0 + \delta_1(Y\text{-}T) + \delta_2(G\text{-}T) + \delta_3 C_{-1} + \delta_4 R$$

$\bar{R}^2$	.999	.999	.999	.999	.999
S.E.	2.23	2.86	4.59	2.02	2.37
D.W.	0.68	1.28	1.02	2.36	2.45

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Table 3
Buiter-Tobin - Regression 1
Dependent Variable PCERP

$$C = \delta_0 + \delta_1(Y-T) + \delta_2 R$$

	ORIG	REPL	TB3R	2SLS
INT	123.4 (4.5)	161.3 (6.3)	161.3 (6.4)	161.4 (6.1)
YDRP	0.875 (100.4)	0.856 (105.5)	0.855 (107.1)	0.854 (99.6)
TB3R	----	----	4.27 (1.4)	9.76 (1.2)
Period	49-76	49-76	49-76	49-76
$\bar{R}^2$	.997	.998	.998	.997
S.E.	27.0	25.5	25.1	26.7
D.W.	1.47	1.67	1.71	1.62

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Table 4
Buiter-Tobin - Regression 2
Dependent Variable PCERP

$$C = \delta_0 + \delta_1(Y-G) + \delta_2 C_{-1} + \delta_3 R$$

	ORIG	REPL	TB3R	2SLS
INT	-135.7	-67.0	-66.6	-64.4
	(3.0)	(1.7)	(1.7)	(0.9)
NIGSRP	0.345	0.404	0.358	0.155
	(5.1)	(5.3)	(4.6)	(0.7)
PCERPL	0.673	0.645	0.689	0.883
	(9.0)	(8.5)	(9.0)	(4.3)
TB3R	—	—	8.52	45.9
			(1.9)	(1.6)
Period	49-76	49-76	49-76	49-76
$\bar{R}^2$	.994	.995	.995	.983
S.E.	39.8	37.1	35.4	69.2
D.W.	1.50	1.69	1.75	1.15

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Table 5
Kormendi - First Differences
Dependent Variable PC1RP

$$C = \delta_0 + \delta_1 Y + \delta_2 Y_{-1} + \delta_3 G + \delta_4 W + \delta_5 TR + \delta_6 D + \delta_7 R$$

	ORIG	REPL	47-76	TB3R	2SLS
INT	not given	9.14 (2.1)	16.2 (2.1)	9.42 (2.0)	7.93 (1.2)
NNPRP	0.33 (14.1)	0.275 (8.7)	0.258 (5.9)	0.271 (7.1)	0.294 (3.5)
NNPRPL	0.05 (2.2)	0.0872 (4.1)	0.0637 (2.2)	0.0866 (4.0)	0.0897 (3.7)
GSRP	-0.21 (3.5)	-0.128 (1.9)	-0.0841 (1.0)	-0.124 (1.7)	-0.146 (1.4)
WRP16	0.032 (3.5)	0.0133 (1.6)	0.0113 (1.2)	0.0138 (1.6)	0.0112 (0.9)

Table 5 (continued)
Kormendi - First Differences
Dependent Variable PC1RP

$$C = \delta_0 + \delta_1 Y + \delta_2 Y_{-1} + \delta_3 G + \delta_4 W + \delta_5 TR + \delta_6 D + \delta_7 R$$

	ORIG	REPL	47-76	TB3R	2SLS
TRRP	0.74 (3.5)	1.000 (6.8)	0.963 (4.7)	1.007 (6.6)	0.970 (5.0)
GBRP	-0.032 (1.6)	-0.0776 (3.6)	-0.0524 (1.7)	-0.0736 (2.6)	-0.0945 (1.3)
TB3R	—	—	—	-0.255 (0.2)	1.087 (0.2)
Period	31-40/47-76	31-40/47-76	47-76	31-40/47-76	31-40/47-76
R̄²	(R²=.910)	.861	.735	.857	.852
S.E.	.0178	19.4	19.8	19.7	20.1
D.W.	1.6	1.79	1.75	1.78	1.82

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Table 6
Feldstein
Dependent Variable PCERP

$$C = \delta_0 + \delta_1(Y\text{-}T) + \delta_2(Y\text{-}T)_{-1} + \delta_3 RE + \delta_4 W + \delta_5 SSW + \delta_6 R$$

	ORIG	REPL	47-71	47-76	TB3R	2SLS
INT	228	244	-110	161	218	-59.0
	(7.4)	(4.5)	(1.2)	(1.9)	(3.9)	(0.1)
YDRP	0.530	0.652	0.707	0.665	0.621	0.303
	(11.3)	(11.1)	(8.6)	(6.2)	(10.2)	(0.5)
YDRPL	0.120	0.110	0.241	0.168	0.133	0.382
	(3.4)	(2.4)	(3.1)	(1.7)	(2.9)	(0.9)
RERP	0.356	0.123	0.148	0.278	0.102	-0.127
	(4.8)	(1.4)	(1.1)	(1.4)	(1.1)	(0.3)
WRP	0.014	0.00864	0.0254	0.00282	0.0131	0.0602
	(3.5)	(1.6)	(3.1)	(0.3)	(2.2)	(0.7)

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Table 6 (continued)
Feldstein
Dependent Variable PCERP

$$C = \delta_0 + \delta_1(Y\text{-}T) + \delta_2(Y\text{-}T)_{-1} + \delta_3RE + \delta_4W + \delta_5SSW + \delta_6R$$

	ORIG	REPL	47-71	47-76	TB3R	2SLS
SSWRP	0.021 (3.5)	0.0122 (1.3)	-0.0540 (3.2)	0.00204 (0.2)	0.0110 (1.2)	-0.00138 (0.04)
TB3R	—	—	—	—	-1.727 (1.5)	-19.9 (0.6)
Period	30-40/47-71	30-40/47-71	47-71	47-76	30-40/47-71	30-40/47-71
$\bar{R}^2$	not given	.999	.998	.997	.999	.987
S.E.	11.0	21.5	17.9	27.4	21.0	66.4
D.W.	1.82	1.41	2.11	1.43	1.54	1.77

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Table 7
Feldstein - Including GBRP
Dependent Variable PCERP

$$C = \delta_0 + \delta_1(Y\text{-}T) + \delta_2(Y\text{-}T)_{-1} + \delta_3W + \delta_4SSW + \delta_5G + \delta_6T + \delta_7TR + \delta_8D + \delta_9R$$

	ORIG	REPL	TB3R	2SLS
INT	-0.413	65.6	-31.4	460.6
	(0.5)	(0.4)	(0.1)	(3.2)
YDRP	0.582	0.686	0.667	0.689
	(2.9)	(8.2)	(6.8)	(8.4)
YDRPL	0.053	0.0339	0.0635	-0.0317
	(0.4)	(0.6)	(0.8)	(0.5)
WRP	0.102	0.0323	0.435	-0.00921
	(1.0)	(2.2)	(1.5)	(0.5)
SSWRP	0.064	0.0171	0.0223	-0.0115
	(0.8)	(1.1)	(0.9)	(1.0)
GSRP	0.927	0.118	0.197	-0.224
	(0.8)	(0.8)	(0.8)	(1.9)
TXRP	-1.734	-0.337	-0.522	0.530
	(0.8)	(1.0)	(0.9)	(2.2)
TRRP	1.256	0.516	0.592	0.115
	(1.0)	(2.2)	(1.7)	(0.6)
GBRP	0.175	0.0614	0.0665	0.0248
	(1.0)	(2.6)	(2.0)	(1.6)
TB3R	–	–	-2.316	5.49
			(0.7)	(1.5)
Period [17]	30-40/47-77	30-40/47-76	30-40/47-76	30-40/47-76
$\bar{R}^2$	---	.998	.998	.999

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Table 7 (continued)
Feldstein - Including GBRP
Dependent Variable PCERP

$$C = \delta_0 + \delta_1(Y-T) + \delta_2(Y-T)_{-1} + \delta_3 W + \delta_4 SSW + \delta_5 G + \delta_6 T$$
$$+ \delta_7 TR + \delta_8 D + \delta_9 R$$

	ORIG	REPL	TB3R	2SLS
S.E.	0.0713	28.8	34.7	26.0
D.W.	1.76	1.69	1.65	1.64
Method	IV	2SLS Single Equation	2SLS Single Equation	2SLS Simultaneous Equation

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Table 8
Estimated Investment Functions
Dependent Variable GIRP
(except Kochin-GIRA)

$$I = \alpha_0 + \alpha_1 Y + \alpha_2 I_{-1} + \alpha_3 R.$$

|	NNPRP	GIRPL	TB3R	Period	$\bar{R}^2$	S.E.	D.W.
1. Kochin-Levels [18]	0.132 (3.2)	0.142 (0.7)	7.33 (2.0)	52-71	.941	7.41	1.61
2. Buiter-Tobin (YDRP)	0.176 (2.7)	0.0825 (0.3)	19.1 (0.6)	49-76	.829	63.9	1.33
3. Buiter-Tobin (NIGSRP)	0.145 (1.8)	0.230 (0.6)	38.0 (1.0)	49-76	.730	85.3	1.24
4. Kormendi	0.402 (5.5)	-0.121 (0.9)	-6.49 (1.3)	31-40/47-76	.584	53.3	1.74
5. Feldstein (1974)	0.167 (6.2)	0.252 (2.1)	-11.7 (3.6)	30-40/47-71	.962	49.7	1.69

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Table 8
Estimated Investment Functions
Dependent Variable GIRP
(except Kochin-GIRA)

$$I = \alpha_0 + \alpha_1 Y + \alpha_2 I\text{-}1 + \alpha_3 R.$$

	NNPRP	GIRPL	TB3R	Period	$\bar{R}^2$	S.E.	D.W.
6. Feldstein (1982a)	0.181 (7.2)	0.170 (1.5)	-9.57 (3.5)	30-40/47-76	.962	52.2	1.59

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Figure 1
The Deficit and the Interest Rate

       The rise in the deficit from DEF to DEF' (due to a tax cut) leads to a rise in savings to S', thus causing the interest rate to rise from R_0 to R_1, according to the standard Keynesian approach. If the Ricardian equivalence theorem holds, however, savings increases from S to S", and the interest rate is unchanged.

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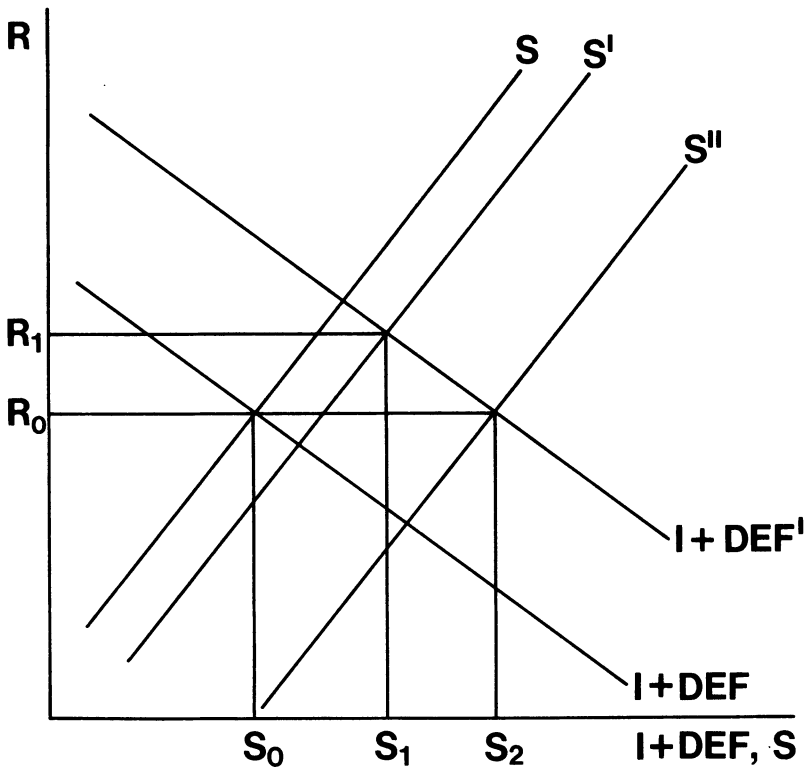
Data Appendix

1. Data from the National Income and Product Accounts (NIPA)

All variables the last two letters of which are RA (e.g., CNDRA) are in real aggregate terms. Real means 1972 dollars. Variables ending in NA (e.g., RENA) are in nominal aggregate terms (billions of dollars). Nominal variables are divided by PCEPD to form real variables. Aggregate variables are divided by POP to form per capita variables, which end in P (e.g., RERA = RENA/PCEPD; RERP = RERA/POP). Lagged variables end in L (e.g., PC2RAL = PC2RA at time t-1). Unless otherwise noted, the variables come from:

1929-1975	-	*National Income and Product Accounts of the United States, 1929-1976* (with corrections in *SCB* July 1982).
1976-1978	-	*Survey of Current Business (SCB)* July 1982.
1979	-	*SCB* July 1983
1980-1983	-	*SCB* July 1984
1983	-	*SCB* October 1985

For each variable below, the NIPA table number is given.

Consumption variables:

CNDRA	=	Personal consumption expenditures on nondurable goods, Table 1.2.
CSRA	=	Personal consumption expenditures on services, Table 1.2.
PCERA	=	Personal consumption expenditures, total, Table 1.2. [PCERA = CNDRA + CSRA + CDRA (durable purchases)]
PCEPD	=	Personal consumption expenditures implicit price deflator, Table 7.1.

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Income variables:

NIRA   =   National income, Table 1.8.

NNPRA   =   Net national product, Table 1.8.

RENA   =   Retained earnings (undistributed corporate profits with inventory valuation and capital consumption adjustments), Table 1.11.

YDRA   =   Disposable personal income, Table 2.1.

Government variables:

FDEFNA   =   Federal government deficit, Table 3.2.

GSRA   =   Government purchases of goods and services, Tables 1.2, 3.8B.

TRNA   =   Total government transfer payments to persons, Table 3.1.

TXNA   =   Total government receipts, Table 3.1.

Other variables:

DURRA   =   Total net stock of durable goods owned by consumers; 1929-1977 from *Fixed Reproducible Tangible Wealth in the U. S., 1925-1979*, Table A16; 1978-1979 *SCB* October 1982, 1980 *SCB* Aug. 1983, 1981-1983 *SCB* Aug. 1984, Table 19.

GINA   =   Gross investment, Table 5.1.

POP   =   Population. 1929-1983 *SCB* July 1984, Table 8.2.

TB3   =   3 month Treasury bill interest rate (auction average), 1929-1938 *Business Statistics (BS)* 1955, p. 82; 1939-1946 *BS* 1965, p. 91; 1947-1960 *BS* 1975, p. 92; 1961-1983 *BS* 1984, p. 65.

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2. Data from non-NIPA sources

GBNA   =   Market value of government debt held by the public, from Seater (1981) - MVTOTG1, Table 1, 1929-1976.

SSWRA   =   Social Security wealth, from Feldstein [13], 1930-1976.

WRA   =   Private fungible wealth, market value, including the value of government debt held by the public, from Feldstein (1982a), 1930-1976.

3. Created variables

NIGSRP   = NIRP - GSRP.

PC1RA   = CNDRA + CSRA + 0.3*DURRA

PC2RA   = CNDRA + CSRA

INFLAT   = inflation rate calculated using PCEPD.

TB3R   = TB3 - INFLAT.

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